An Ecological Assessment of the Georgia Basin-Puget Trough-Willamette Valley Ecoregion: An Analysis to Identify, Integrate and Prioritize Areas of Freshwater, Terrestrial and Marine Biodiversity Significance

Mark Goering
The Nature Conservancy, Seattle

Terry Cook
The Nature Conservancy, Charlottesville, VA

Zach Ferdana John Floberg Tracy Horsman *and* ***Marcy Summers***
The Nature Conservancy, Seattle

Chuck Rumsey *and* ***Pierre Iachetti***
The Nature Conservancy of Canada, Victoria, BC

Abstract
The Nature Conservancy of Canada, The Nature Conservancy (U.S.), and their provincial, state and federal partners, have completed a transboundary conservation planning strategy for the Georgia Basin, Puget Trough and Willamette Valley ecoregion which identifies areas of biodiversity significance containing multiple, viable (or feasibly restorable) examples of all native plants, animals, and ecological communities across important environmental gradients.

To achieve this goal, we used the "coarse-fine filter strategy," a working hypothesis that assumes conservation of multiple, viable examples of all coarse-filter targets (communities and/or habitat types) will also conserve the majority of species. Those species that the coarse filter cannot reliably conserve require individual attention through the fine filter approach (e.g., wide-ranging, rare, narrowly endemic, or keystone species).

The results of this planning project yielded a portfolio or network of lands and waters for conserving the elements of biodiversity within the ecoregion that best represents the native species and ecosystems of the region and the underlying ecological processes that sustain those (Groves *et al.* 2002).

Ecoregions, not political boundaries, provide a framework for capturing ecological and genetic variations in biodiversity across a range of environmental gradients. This strategy provides a more practical alternative to surveying every species, and provides a cost-effective means for simultaneous conservation and recovery of groups of species (Simberloff 1997). Protecting and restoring ecosystems also serves to protect species about which little is known and provides the opportunity to protect species while they are still common (Noss 1990).

Introduction
The Nature Conservancy (U.S.) and the Nature Conservancy of Canada, along with a variety of state, provincial, and federal partners, conducted an ecological assessment of the Georgia Basin-Puget Trough-Willamette Valley ecoregion for the purpose of identifying and prioritizing biologically significant areas. This group of conservation areas represents our best attempt, given current knowledge, to depict a set of locations that, if properly managed, would conserve all biodiversity representative of this ecoregion. The assessment used a combination of coarse filter targets (ecological systems) and fine filter targets (species and natural communities) to identify terrestrial, freshwater, and marine areas of biological significance. The total number of targets used in the assessment was 867. Number and area goals for all targets were developed and used to identify the conservation areas using the SITES computer model. Separate model runs for terrestrial, freshwater, and marine targets were performed using three separate 'cost' or suitability indices. These indices, based upon such factors as road density, dam density, land ownership, zoning, land- cover, etc. are used to help determine the most efficient selection of sites. Terrestrial, freshwater and marine sites were then integrated through GIS overlay and refined through expert review. Three hundred and 43 areas of biological significance were identified during the assessment representing 24% of the total land and 9% of the total marine area of the ecoregion.

Ecoregional Planning

Ecoregions are areas of land and water defined by similar geology, landforms, climate, vegetation, and ecological processes. About 80 ecoregions have been identified within Canada, the United States and Mexico. *Ecoregional planning* is the process we use to set our conservation priorities (i.e. to identify areas of biodiversity significance). The ecoregional planning process is used to select general areas in which conservation action is needed; this is followed by more detailed planning, action, and monitoring at specific sites.

The analysis is designed to serve four well-accepted goals of conservation: (1) represent ecosystems across their natural range of variation; (2) maintain viable populations of native species; (3) sustain ecological and evolutionary processes; and (4) build a conservation network that is resilient to environmental change. In pursuit of these goals, this ecoregional plan integrated two basic approaches to conservation planning:

- Representation of a broad spectrum of environmental variation (e.g., vegetation, geo-climatic, and aquatic classes).
- Protection of special elements: concentrations of ecological communities; rare or at risk ecological communities; rare physical habitats; concentrations of species; locations of at risk species; locations of highly valued species or their critical habitats; locations of major genetic variants.

The eco-regional planning process has two steps: (1) data development and analysis, and (2) portfolio development and assessment. The first step involves assembling relevant data on the eco-region's species and communities (termed "conservation targets") and their known locations. The second step selects the most efficient group of sites that collectively meet conservation goals for all of the eco-region's conservation targets.

Once the commitment to conserving a significant amount of biodiversity is made, there is a need to explicitly identify which parcels of land, or locations, henceforth called sites, should be preserved. A common mechanism used to identify sites for protection is to set as a goal some minimum representation of biodiversity features for the smallest possible cost. The results of this procedure are a discrete set or portfolio of sites that presumably protect biodiversity features efficiently. An important caveat to such an effort is that just because the minimum representation level is protected does not ensure that such a reserve system is adequate.

Such a set of goals requires a replicable procedure for identifying the set or portfolio of sites that achieve these goals. Early attempts to solve this problem have included heuristic decision support tools and the greedy algorithm which "greedily" attempts to maximize the rate of progress towards the objective at each step by selecting the best available sites sequentially until limits, such as the cost or size of the reserve system, are reached. More recent models have achieved enhanced efficiency in selecting sites by beginning with a random set of parcels and iteratively examining various combinations of sites while the model seeks to minimize the 'cost' to protect the set of sites. This mechanism enables the decision-making algorithm to select the set of sites that achieves the prescribed goals most efficiently and is able to avoid the pitfalls of adding sites sequentially because it is able to experimentally exclude any site after its inclusion. Just this sort of decision making tool has been provided to a broad audience as a software extension to ESRI's ArcView GIS software.

Developed for The Nature Conservancy in 1999, SITES is an analytical tool developed to aid scientists and land managers in their attempts to identify a portfolio or group of areas for conservation. SITES uses as its primary inputs species records which have been put into a digital format. The goal of this program is to minimize the cost of the total portfolio according to the following simple formula:

Total Portfolio Cost = (cost of selected sites) + (penalty cost for not meeting the stated conservation goals for each species or element) + (cost of spatial dispersion of the selected sites as measured by the total boundary length of the sites in the portfolio).

More information about this particular analytical tool can be found by visiting the following website: http://www.biogeog.ucsb.edu/projects/tnc/toolbox.html.

Criteria for Identifying Conservation Targets

The first critical step in ecoregional conservation planning is to identify conservation targets—species, natural communities and/or ecological groups that will be the focus of planning efforts.

Because it is impractical to plan for all of the targets, even all of those that are known, we must select a subset of targets at different spatial scales and levels of biological organization that will best represent all biological diversity.

The goal of ecoregional planning is to identify areas of biodiversity significance that contain multiple, viable (or feasibly restorable) examples of all native plants, animals, and ecological communities across important environmental gradients. To achieve this goal, we use the "coarse-fine filter strategy," a working hypothesis that assumes conservation of multiple, viable examples of all coarse-filter targets (communities and/or habitat types) will also conserve the majority of species. Those species that the coarse filter cannot reliably conserve require individual attention through the fine filter approach (e.g., wide-ranging, rare, narrowly endemic, or keystone species).

Fine Filter (Species) Targets

In our site selection process, we use the fine filter to collect data on known sites, or "occurrences," of populations of our fine filter targets—targets that may not be adequately conserved through protection of habitat types alone. These fine filter occurrences are then combined with habitat areas selected through the coarse filter to create the complete portfolio of sites for conservation.

Species that meet any *one* of the following criteria are considered candidates for our conservation targets list.

- **Imperiled species** have a global rank of G1-G3 by U.S. Natural Heritage Programs/ Canadian Conservation Data Centres. Regularly reviewed and updated by experts, these ranks take into account number of occurrences, quality and condition of occurrences, population size, range of distribution, threats and protection status.
- **Endangered and threatened / B.C. red-listed species** are those federally listed or proposed for listing as Threatened or Endangered by the U.S. Fish and Wildlife Service under the Endangered Species Act or coded "red" by the B.C. Provincial Government.
- **Species of special concern**
    - **Declining species:** Declining species exhibit significant, long-term declines in habitat/and or numbers, are subject to a high degree of threat, or may have unique habitat or behavioral requirements that expose them to great risk.
    - **Endemic species:** Endemic species are restricted to an ecoregion (or a small geographic area within an ecoregion), depend entirely on a single area for survival, and are therefore often more vulnerable.
    - **Disjunct species:** Disjunct species have populations that are geographically isolated from other populations.
    - **Vulnerable species:** Vulnerable species are usually abundant, and may or may not be declining, but some aspect of their life history makes them especially vulnerable (e.g., migratory concentration or rare/endemic habitat). For example, sandhill cranes are a vulnerable species because a large percentage of the entire population aggregates during migration along the Platte River in Nebraska.
    - **Keystone species** are those whose impact on a community or ecological system is disproportionately large for their abundance. They contribute to ecosystem function in a unique and significant manner through their activities. Their removal initiates changes in ecosystem structure and often a loss of diversity (e.g. salmon, beaver, and sea urchin).
    - **Wide-ranging species** (i.e. regional) depend on vast areas. These species include top-level predators (e.g. orca) as well as migratory mammals (e.g. gray whale), anadromous fish, birds, and insects. Wide-ranging species can be especially useful in examining necessary linkages among conservation sites in a true "network" of sites.
- **Special Consideration:** These are unique, irreplaceable sites for the species that use them, or are critical to the conservation of a certain species or suite of species.
    - **Globally significant examples of species aggregations** (i.e., critical migratory stopover sites that contain significant numbers of migratory individuals of many species). For example, significant migratory stopovers for shorebirds have been formally designated through the Western Hemisphere Shorebird Reserve Network.
    - **Major groups of species that share common ecological processes and patterns,** and/or have similar conservation requirements and threats (e.g. dabbling ducks, freshwater mussels). It is often more practical in eco-regional plans to target such groups as opposed to each individual species of concern.

Assessing Occurrence Viability and Developing Conservation Goals

Conservation goals represent the end toward which conservation efforts are directed for targeted species and ecological communities. Defining goals is one of the most difficult, and most important, scientific questions in biodiversity conservation (e.g., How much is enough? How many discrete populations in what spatial distribution are needed for long-term viability?). For our purposes, we define a **viable species** or **population** as one that has a high probability of continued existence[1] in a state that maintains its vigor and potential for evolutionary adaptation[2] over a specified period of time. This same definition extends to multiple species that characterize recurring ecological communities.

Our experience to date suggests several practical approaches to this issue. First, it is helpful to view conservation goals as addressing questions of species viability and ecosystem integrity at multiple scales. We first assess the local-scale occurrence of a given target species or community and evaluate the ***size, quality/condition,*** and ***landscape context*** of the example, relative to other, apparently viable/ functional examples. Criteria in these categories are briefly defined as:

Size is a measure of the area or abundance of the conservation target's occurrence, relative to other known, and/or presumed viable, examples. For habitats and communities, size is simply a measure of the occurrence's patch size or geographic coverage. For animal and plant species, size takes into account the area of occupancy and number of individuals. Minimum dynamic area, or the area needed to ensure survival or re-establishment of a target after natural disturbance, is another aspect of size.

Quality/Condition is an integrated measure of the composition, structure, and biotic interactions that characterize the occurrence. This includes factors such as *reproduction, age structure, biological composition* (e.g., presence of native versus exotic species), *structure* (e.g., relief versus complexity in rocky reef habitats), and *biotic interactions* (e.g., levels of competition, predation, and disease).

Landscape context is an integrated measure of two factors: the dominant environmental regimes and processes that establish and maintain the target occurrence, and connectivity. *Dominant environmental regimes and processes* include hydrologic and water chemistry regimes (current and tidal), geomorphic processes, climatic regimes, temperature and precipitation, and many kinds of natural disturbances. *Connectivity* includes such factors as species targets having access to habitats and resources needed for life cycle completion, fragmentation of ecological communities and systems, and the ability of any target to respond to environmental change through dispersal, migration, or re-colonization.

Once we have identified a set of occurrences for each species and community that would likely remain viable/functional (usually requiring good stewardship), we may then address questions of viability and ecosystem integrity for each target species and community throughout the eco-region, and range-wide.

There is little empirical research that addresses representation goals of species and ecological communities, though meta-population theory and population viability analyses offer some insights into this issue. In general, we are looking to conserve a combination of "core" interconnected populations along with outlying, unconnected isolates. The relative emphasis on interconnected vs. isolated populations may vary, depending on the species/community. For example, with species that typically occur in small, isolated habitats, the probability of long-term species survival may increase by protecting numerous, isolated populations. On the other hand, wide ranging species may be protected with a greater emphasis on habitat connectivity among fewer, discrete sub-populations. **Given the limits of current knowledge, we state conservation goals simply as initial objectives.** They must be tested and refined through time by monitoring the status and trends of individual species and ecological communities.

As a general rule, conservation of multiple examples of each target, stratified across its geographic range, is necessary to capture the variability of the target and its environment, and to provide replication to ensure persistence in the face of environmental stochasticity and likely effects of climate change. Given the complexity of this topic, we ask that each expert focus on a set of key questions that will inform the ecoregional planning team as they establish conservation goals.

Notes

[1] 95% certainty of surviving 100 years and/or 10 generations.

[2] Potential for adaptation implies that the species or population has sufficient genetic variation to adapt by natural selection to changing environmental conditions within a predicted range of frequency and amplitude of disturbance and change.

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